Pixel Overview and Requirements

May 26, 1999

Inner Detector Cooling Review

Session 3.1

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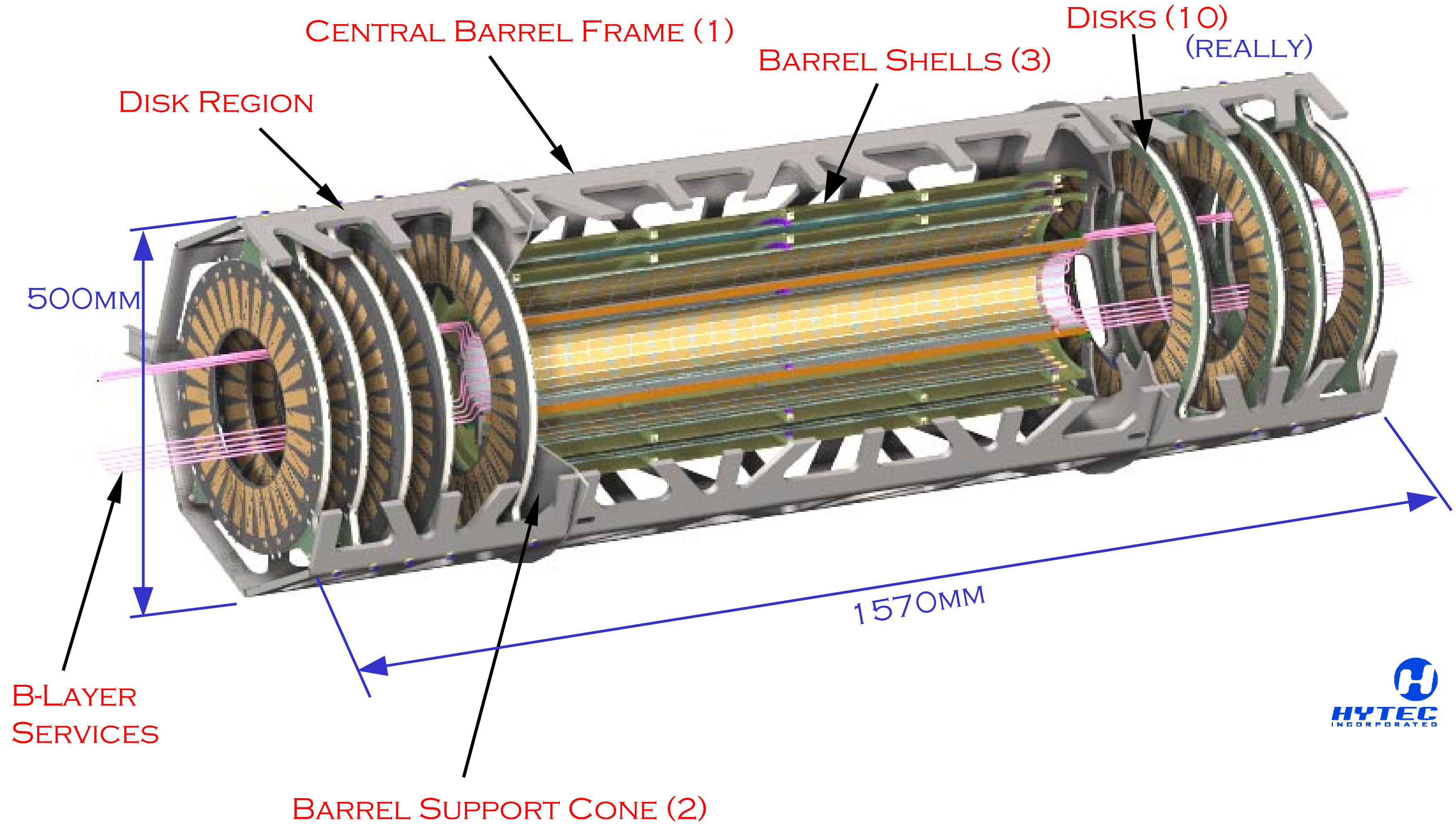
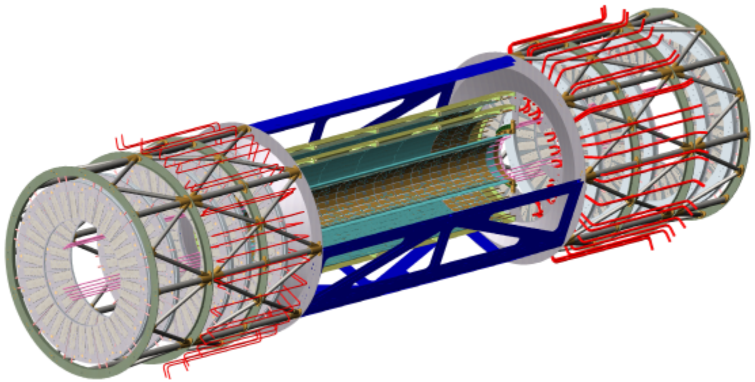
Pixel Detector

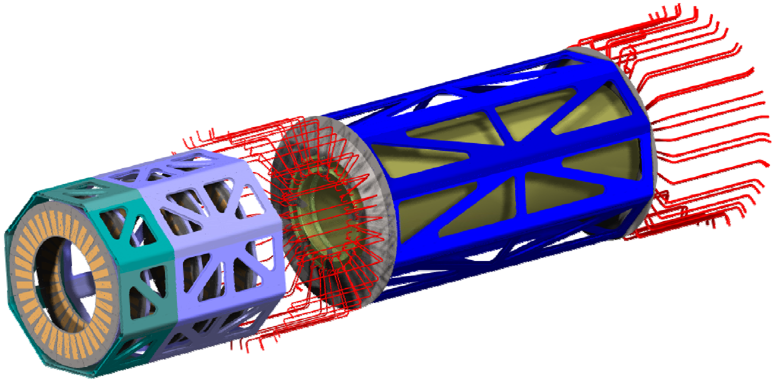
General Layout



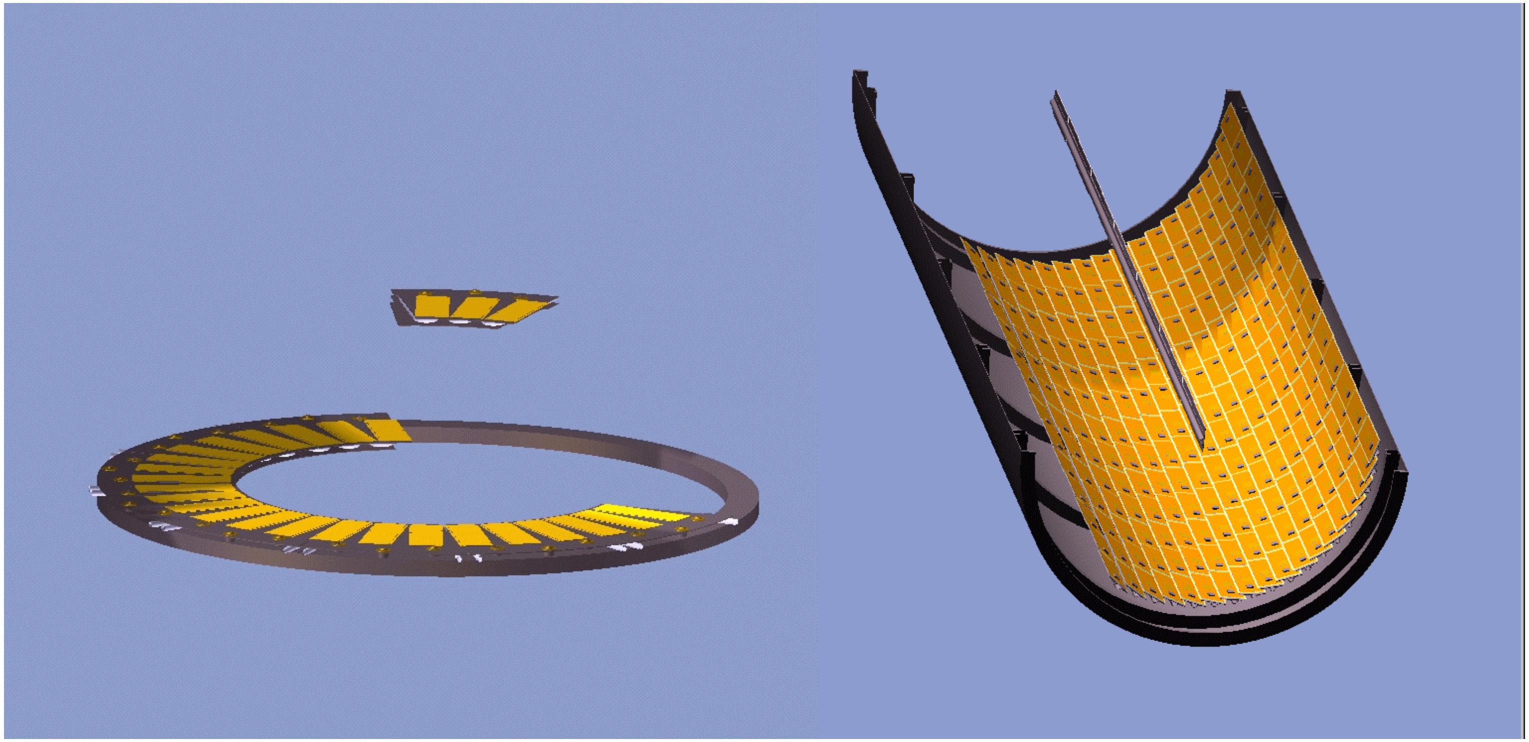
Brief History of Layout

- **Baseline Design in TDR has tubular truss end frames with disks that extend past Z=800**
- **Progression of design important to remember:**
  - Baseline in TDR
  - Costing
  - Analysis
  - Material Estimates
  - Structural Performance
  - Service Space/Routing
- **Forward changed to flat panel to reduce cost**
- **Changed again to Z<780 Layout of Disks for ID integration reasons**





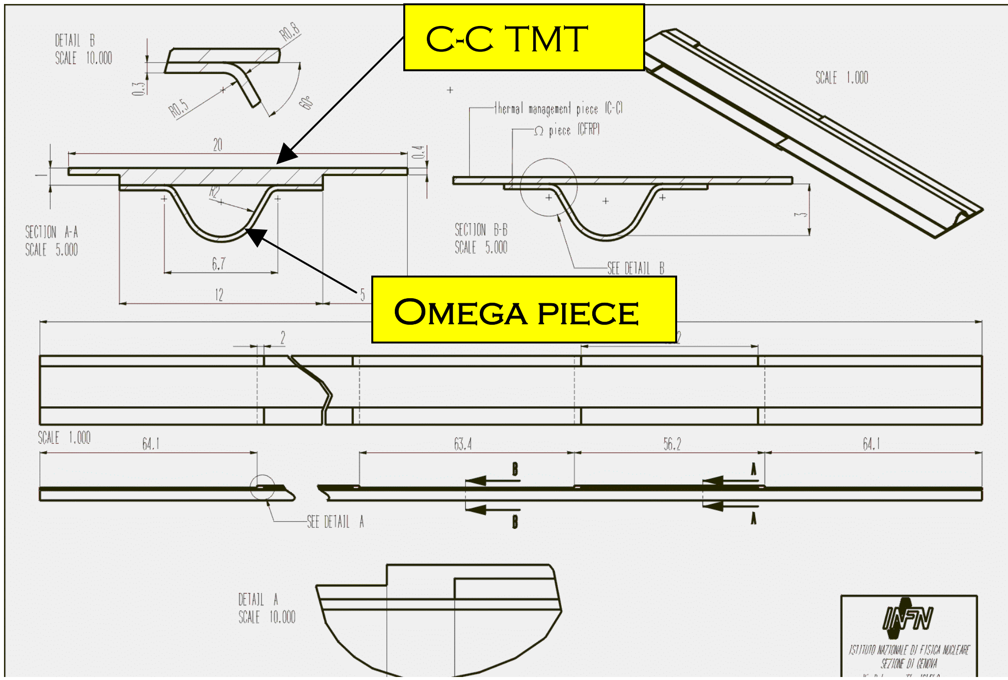
Cooling Sub-Structures

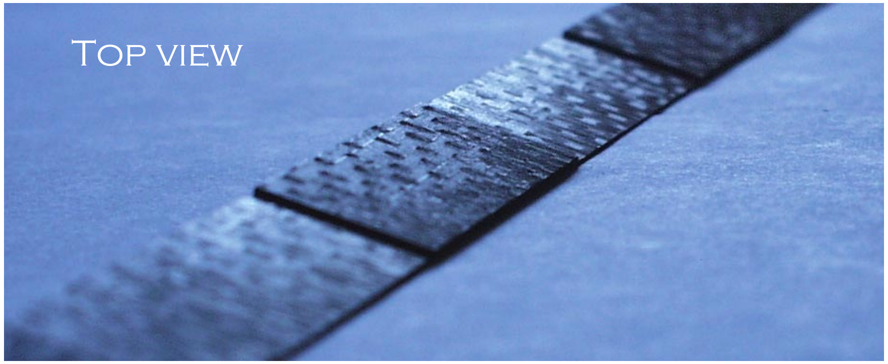


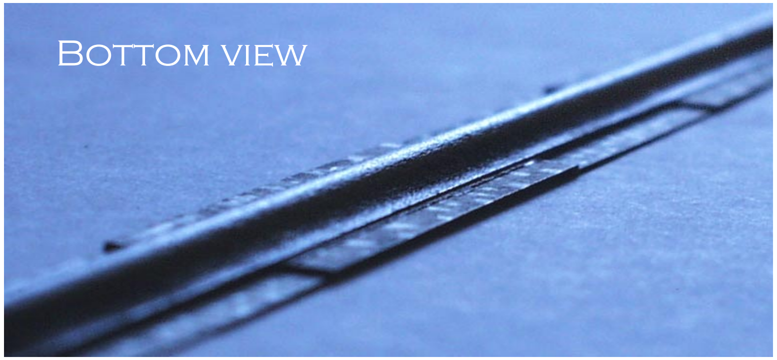
- **Sectors and Staves are modular cooling elements which are assembled into Disks and Barrels respectively**
  - 6 modules per sector and 13 per stave
  - There are 2 sectors/staves per cooling circuit
- **Heat is extracted from these structures via structurally integrated cooling channels**

Stave Baseline

- Cooling tube made of an Omega-shaped CFRP part glued to a Carbon-Carbon (C-C) Thermal Management Tile (TMT)
- TMT machined from a C-C plate and impregnated to seal porosity
  - Shingled Geometry accepted as baseline Jan99 (not shown)
  - Baseline design assumes evaporative cooling and under-pressure operation

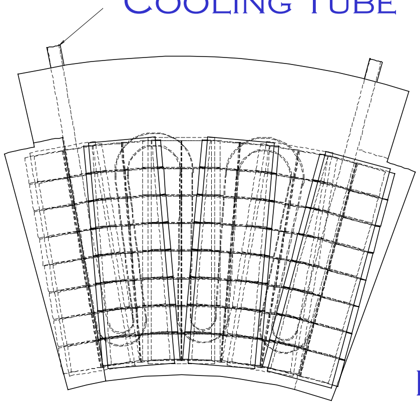




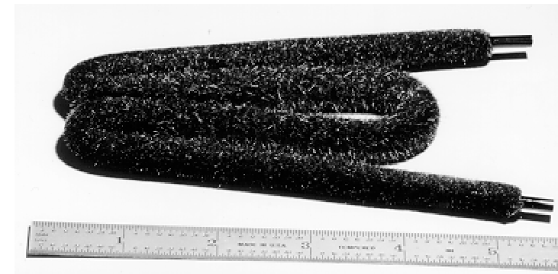


Sector Baseline

Cooling Tube

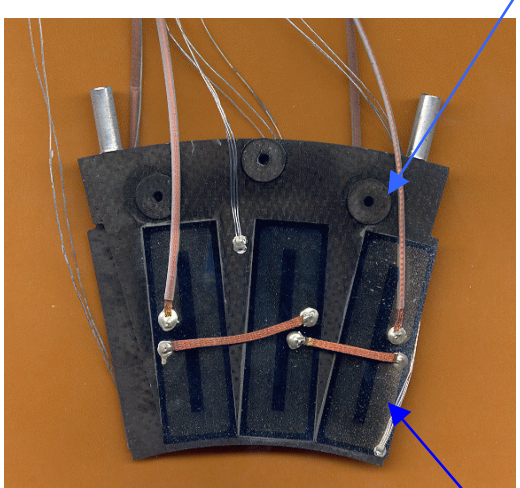


ESLI prototype #8 it is the first one with the newer 5 disk layout as defined in the TDR

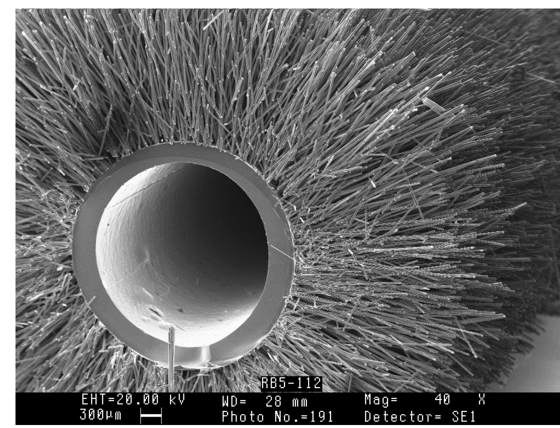


ESLI flocked glassy carbon Tube (Old 4 disk design)

Mounting Pads
(not shown above)



Backup effort includes both CC tube option and aluminum tube options.

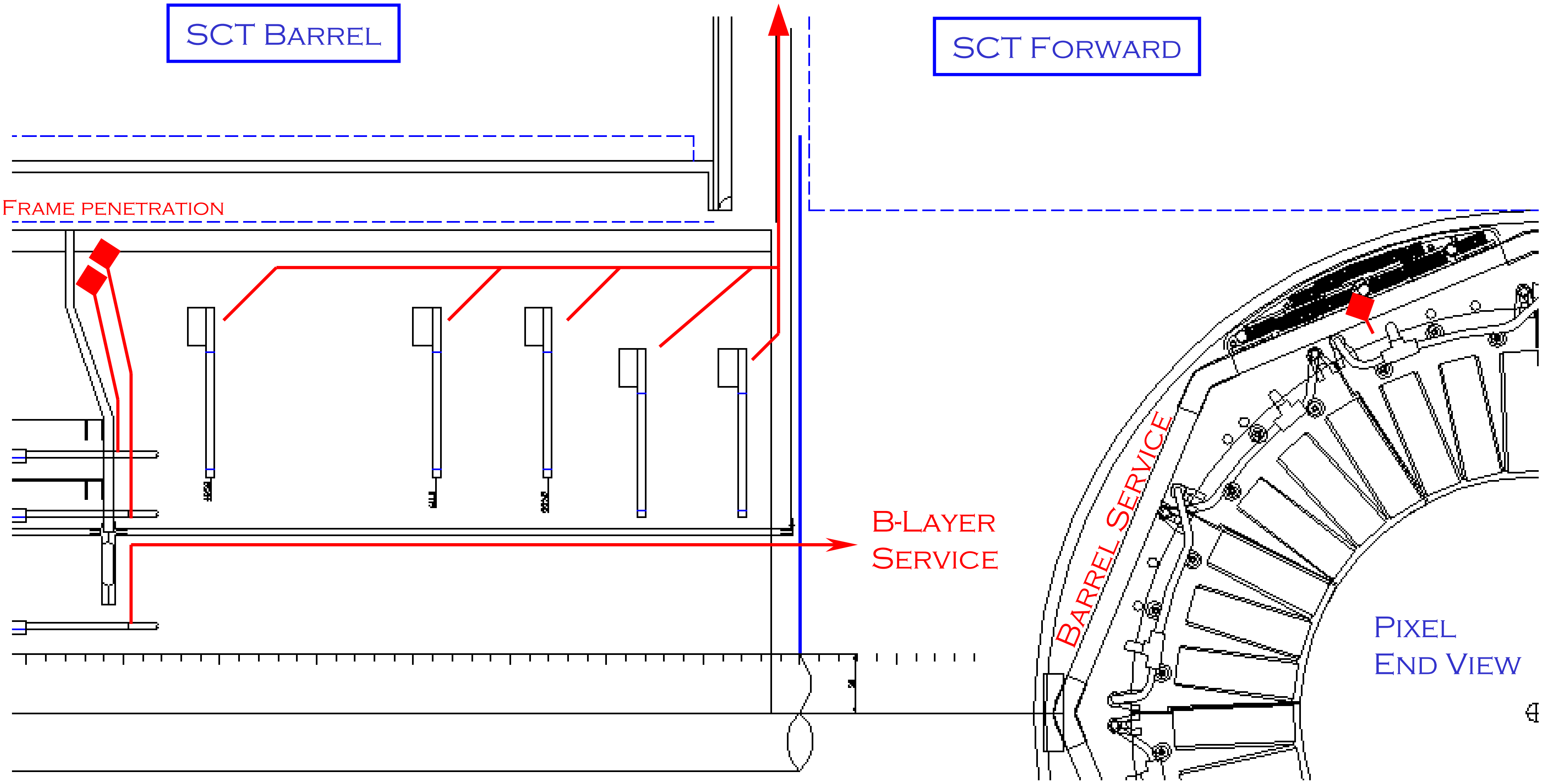


Section through tube

Heaters

Pixel Detector

Service Routing



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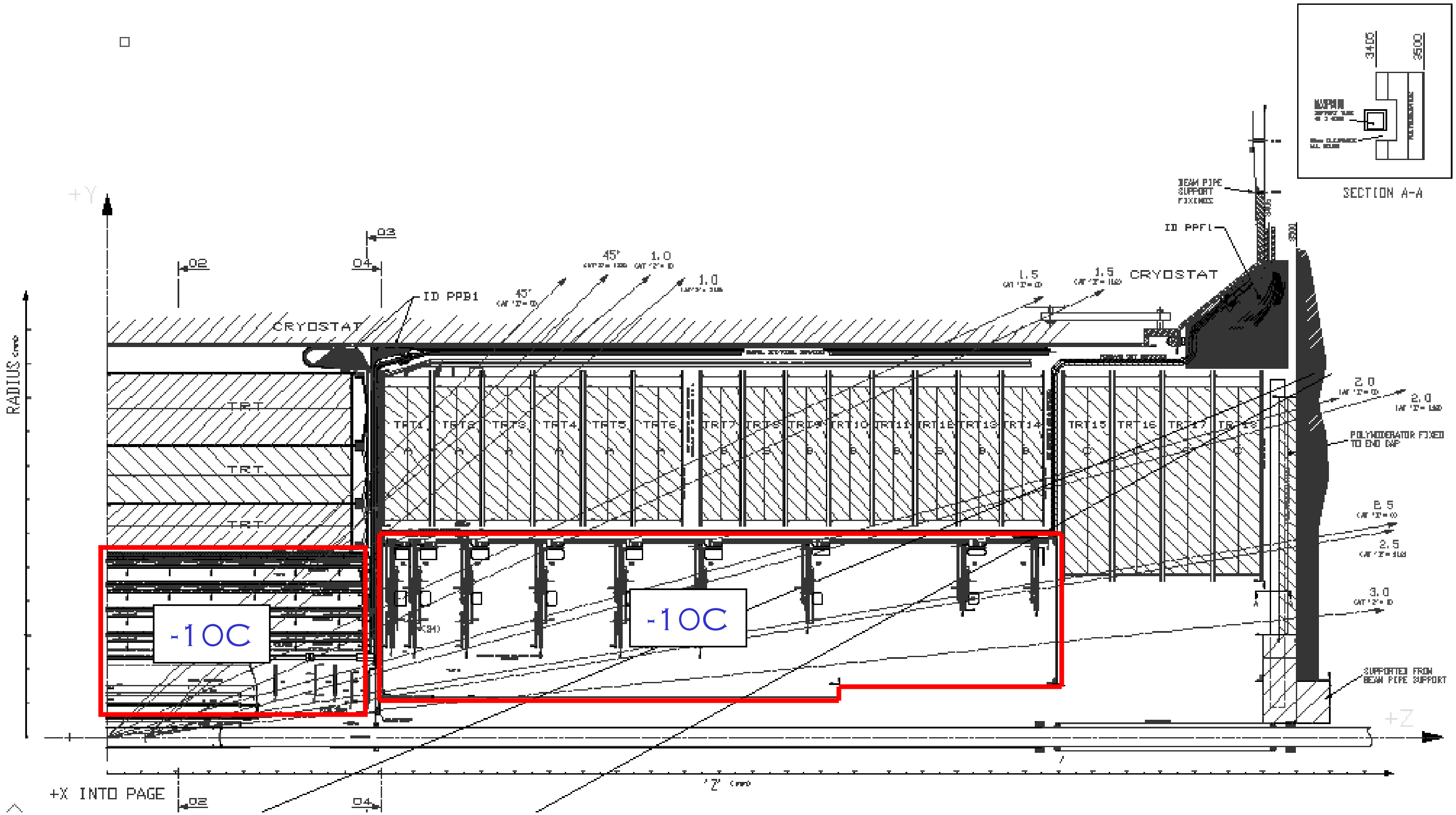
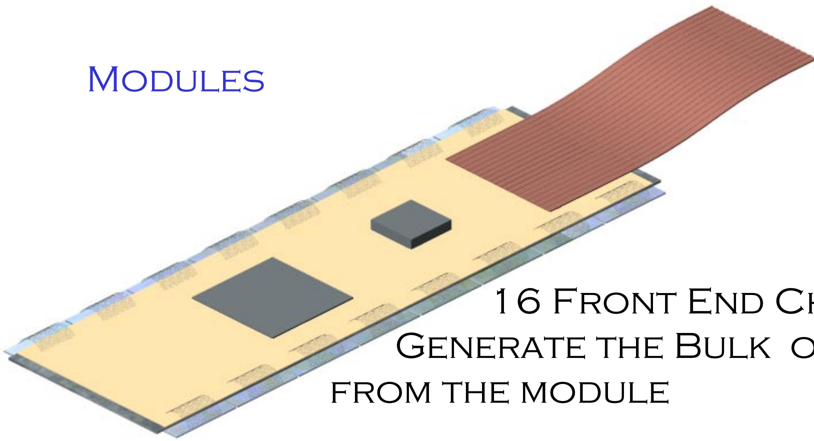
Pixel Local Environment



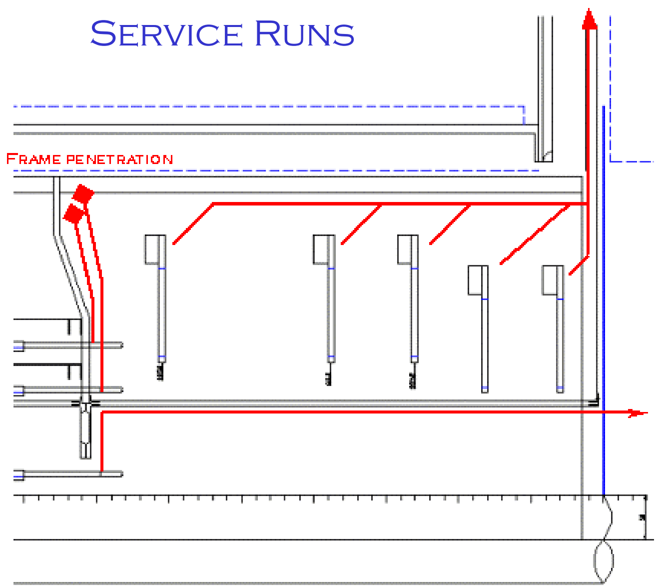
Heat Sources

Modules



16 Front End Chips Generate the Bulk of heat from the module

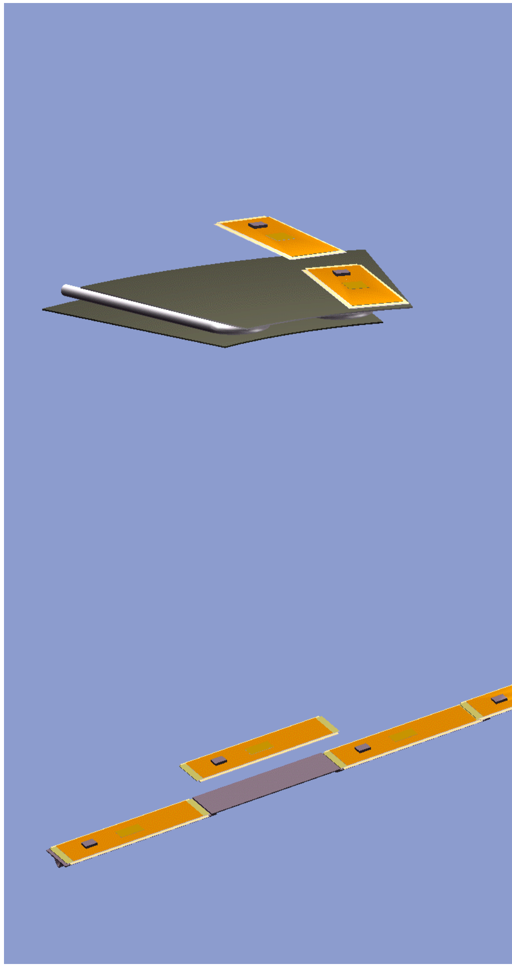
Service Runs



- **Module Loads**
  - Module: 7.75W
  - B-Layer Module: 9.60W
- **Pigtails**
  - Maximum Pigtail: 0.51W
    - adds to each module
- **Sector/Stave Summary**
  - Barrel Stave: 107W
    - 13 Modules + Pigtails
  - B-Layer Stave: 134W
    - 13 Modules + Pigtails
  - Sector: 49.5W
    - 6 Modules +Pigtails
- **Service run (Excess)**
  - Beyond Pigtail: 1.09kW
    - 1994 Modules inside thermal Barrier

Heat Extraction

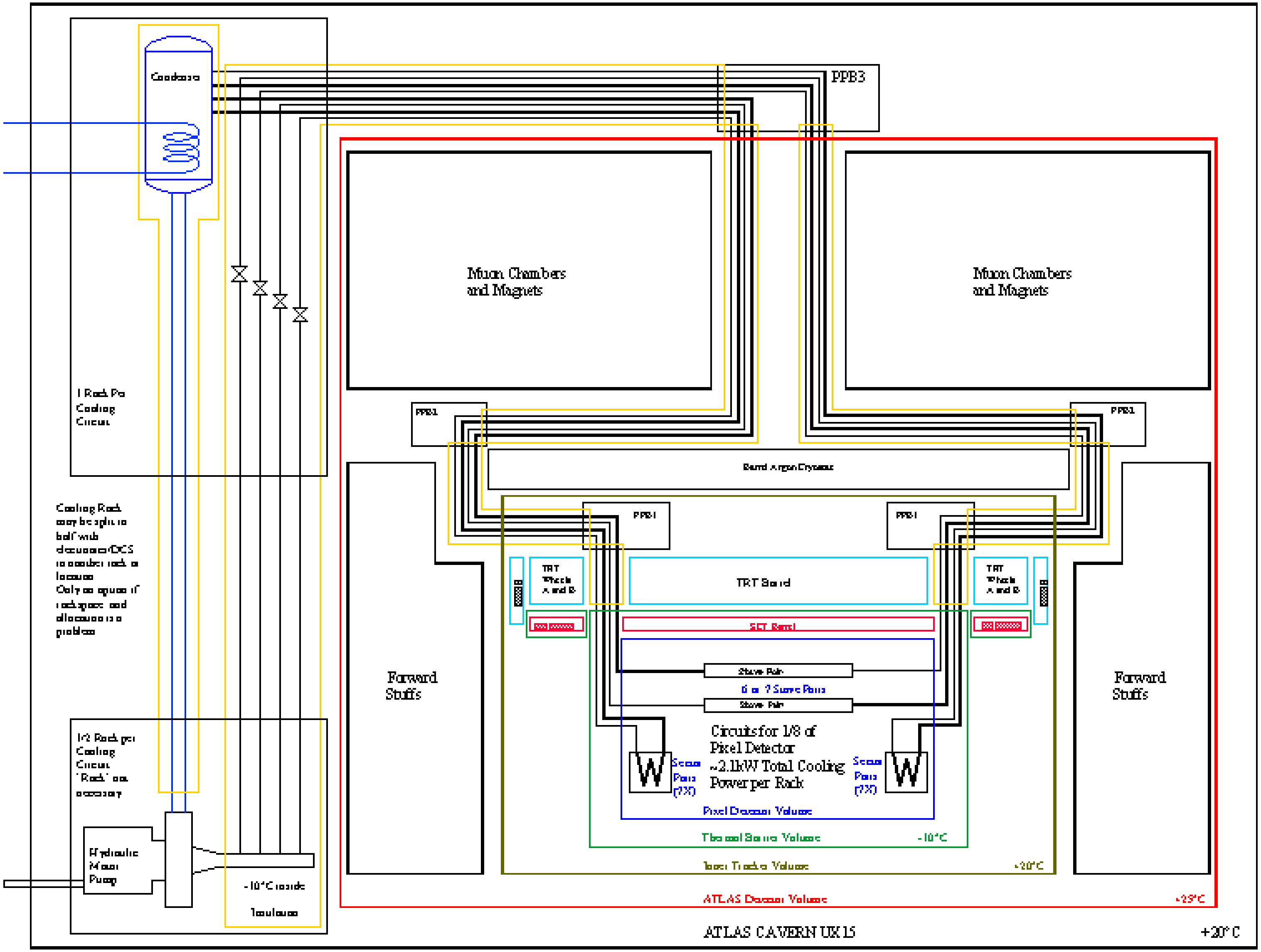
- **Modules are placed directly onto Thermal Management structures for a highly integrated low mass design**
  - Heat load is distributed over entire surface of module
  - Modules are placed on cooling structure to provide good thermal contact
  - Accuracy of detector is tied to accuracy and stability of thermal management structure
- **Cooling Channels are integrated into structures and are used structurally**
  - Different from SCT approach
- **Optimization for heat transfer into fluid leads to flattened tubes**
  - Stave is non symmetric, Sector is "Ovalized"
  - Geometries are not ideal for high internal pressures



Design Considerations

- **Temperature of Silicon**
  - -6C (negative) or lower
- **Low Thermal Impedance between Coolant and Module**
  - Absolute temperature difference between cooling channel and silicon leads to bi-metallic effect (induced moment) in structures
  - Leads to coolant temperature spec (-20 has been adopted, but is not a hard number)
- **Low overall pressure drop**
  - Pressure drop in Stave is significant portion of overall pressure drop for low pressure system--needs to be minimized (3 bar is viewed as a safe limit)
  - Overall pressure drop must be low, not just operating pressure
  - Two Staves in parallel most demanding circuit

Pixel Detector

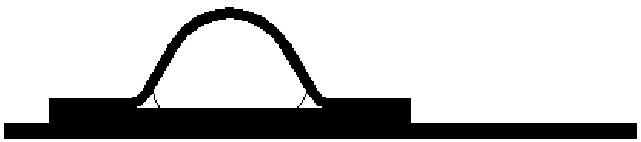


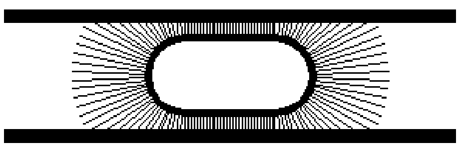
Services

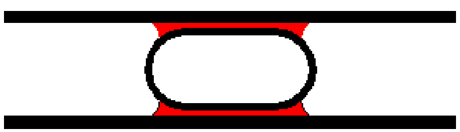
- **Service routing baselined for monophase coolant**
- **Evaporative service layout underway**
  - Appears to fit within Pixel Volume
  - Some leeway available with cable selection to allow space
- **Cross-sectional area for evaporative is less, but (exhaust) tubing diameters are singly larger**
  - Service layout is based on equal tubing diameters
- **Evaporative Tubing sizes for full system being calculated**
  - To be verified in Phase II of cooling program

Pressure Considerations

Current Designs



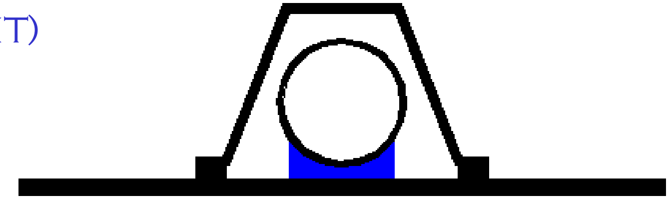


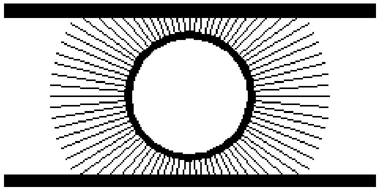


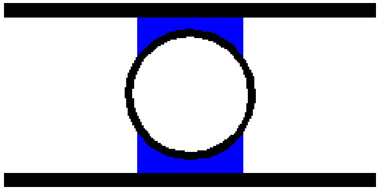
Designs progressed from round tubes to ovalized tubing to maximize heat transfer from the fluid to the cooled structure (TMT) Pressure was not part of the optimization.

Going "back" to a higher pressure configuration leads to lower thermal contact and increased mass compared to current designs for our structures

Designs consistent with high pressure operation







Section through cooling channels

Summary

- **Current Pixel baseline is evaporative C4F10**
  - Structures have been cooled, however system studies remain
- **Calculations to be presented are for 2 staves in parallel, not B-Layer staves**
  - this is the worst case for a given circuit
- **Tests to be presented are on structures which were designed for 0.6W/cm^2**
  - Power increased to 0.83W/cm^2 (1.0W/cm^2--B-layer)
- **Differences in Geometric constraints between Pixels and SCT lead to differing levels of integration of cooling and structure**
  - Integrated cooling channels have lower mass
  - Low temp difference is more geometrically stable
- **Pixels desire a common solution with the SCT at the lowest possible pressure**